

REMARKS

Claims 1-7, 9, 11-23 and 25-27 remain in this application. Claims 1, 9, 13, 14 23 and 27 have been amended and claims 8, 10 and 24 cancelled.

Examiner Kin Chan Chen is thanked for having thoroughly examined the present invention.

The limitation "by etching" in claim 10 has been incorporated into claim 1, and, accordingly, claim 10 has been cancelled. It is believed that, that claim 10 is objected to, is now moot.

Reconsideration of the rejection of claims 1, 2, 4, 5, 7 and 9-13 under 35 USC 103(a) as being unpatentable over Lin, et al., (U.S. 6,042,999) in view of Wang, et al., (U.S. 6,057,239) is respectfully requested in view of the amendments and for the reasons given below.

Claim 1 has been amended twice to distinguish the present invention from the reference. The limitation cited in claims 8 and 10 have been incorporated into claim 1.

Thus, claim 1 now cites the fill material comprising I-line photo resist, which the cited references lack. Claim 1 has been amended to cite the removal of the excess fill material by etching, or by chemical mechanical polishing. The method of chemical mechanical polishing is totally lacking in both of the cited references of Lin and Wang. In Wang, the sacrificial layer is anisotropically etched using plasma. Lin does not even use I-line photo resist as a fill material, and he/she too relies on etching, not chemical mechanical polishing, to remove the BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant goes to great lengths in disclosing that conventional etching processes introduce moisture into insulative layers (page 18, lines 1-3), giving rise to voids, cavities for contaminants to enter, poor interfaces between contacting conductors, and hence, poor connections between interconnects. It is also disclosed that low-k materials are susceptible to form interactions with photore-sist materials, and hence etching can leave behind photore-

sist reside, which are detrimental in forming poisoned contact/via holes (page 18, lines 13-20).

As further stated starting on line 15 on page 19 of the instant specification:

It is a main feature and key aspect of the present invention, therefore, to fill the hole opening with a material that will not only protect the via from poisoning, but also from volcano effect. It is disclosed hereby that the proper fill material is a specific photoresist, namely, I-line photoresist (line-line PR), or, a spin-on organic oxide such as SiLK and FLARE. An added advantage of using the line-line photoresist is that it is more suitable, in comparison with DUV-PR, for higher wavelength radiation that is needed for patterning deep submicron features of today's ULSI technology.

The applicant further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using etching. Neither Lin nor Wang contemplate the problems associated with moisture when etching filling materi-

als specifically in dual damascene structures, and the attendant volcano effect.

In view of the amendments and the reasons given above, it is believed that base claim 1 is clearly distinguishable from the cited references, and therefore, allowable, and hence also claims 2, 4, 5, 7 and 9-13 dependent from claim 1, and it is so requested, respectfully.

Reconsideration of the rejection of claims 3 and 6 under 35 USC 103(a) as being unpatentable over Lin, et al.; (US Patent 6,042,999) and Wang, et al., (US 6,057,239), and further in view of Tsai, et al (US 6,326,296 B1) is respectfully requested in view of the amendments and for the reasons given below.

Claim 1 has been amended twice to distinguish the present invention from the reference. The limitation cited in claims 8 and 10 have been incorporated into claim 1. Thus, claim 1 now cites the fill material comprising I-line photo resist, which the cited references lack. Claim 1 has been amended to cite the removal of the excess fill material by etching, or by chemical mechanical polishing. The method of chemical mechanical polishing is totally lacking

in both of the cited references of Lin and Wang. In Wang, the sacrificial layer is anisotropically etched using plasma. Lin does not even use I-line photo resist as a fill material, and he too relies on etching, not chemical mechanical polishing, to remove the BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using etching. None of the cited references contemplate the problems associated with moisture when etching filling materials specifically in dual damascene structures, and the attendant volcano effect.

In view of the amendments and the reasons given above, it is believed that base claim 1 is now clearly distinguishable from the cited reference, and therefore, allowable, and hence also claims 3 and 6 dependent from claim 1, and it is so requested, respectfully.

Reconsideration of the rejection of claims 14-16, 18, 19, 21-23 and 25-27 under 35 USC 103(a) as being unpatentable over Lin, et al., (US Patent 6,042,999) in view of admitted art and Wang, et al., (US 6,057,239) is respectfully requested in view of the amendments and for the reasons given below.

Claim 14, as amended previously, cites the fill material comprising I-line photo resist, which the cited references lack. Claim 14 also cites the removal of the excess fill material by chemical mechanical polishing. The method of chemical mechanical polishing is totally lacking in the cited prior art as well in the references of Lin and Wang. In Wang, the sacrificial layer is anisotropically etched using plasma. Lin does not even use I-line photo resist as a fill material, and he/she too relies on etching, not chemical mechanical polishing, to remove the BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant goes to great lengths in disclosing that conventional etching processes introduce moisture into insulative layers (page 18, lines 1-3), giving rise to voids, cavities for contaminants to enter, poor interfaces between contacting conductors, and hence, poor connections between interconnects. It is also disclosed that low-k materials are susceptible to form interactions with photoresist materials, and hence etching can leave behind photoresist residue, which are detrimental in forming poisoned contact/via holes (page 18, lines 13-20).

As further stated starting on line 15 on page 19 of the instant specification:

It is a main feature and key aspect of the present invention, therefore, to fill the hole opening with a material that will not only protect the via from poisoning, but also from volcano effect. It is disclosed hereby that the proper fill material is a specific photoresist, namely, I-line photoresist (line-line PR), or, a spin-on organic oxide such as SiLK and FLARE. An added advantage of using the line-line photoresist is that it is more suitable, in comparison with DUV-PR, for higher wavelength radiation

that is needed for patterning deep submicron features of today's ULSI technology.

The applicant further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using etching. Neither Lin nor Wang contemplate the problems associated with moisture when etching filling materials specifically in dual damascene structures, and the attendant volcano effect.

In view of the amendments and the reasons given above, it is believed that base claim 14 is clearly distinguishable from the cited references, and therefore, allowable, and hence also claims 15, 16, 18, 19, 21-23 and 25-27 dependent from claim 14, and it is so requested, respectfully.

Reconsideration of the rejection of claims 17 and 20 under 35 USC 103(a) as being unpatentable over Lin, et al., (US Patent 6,042,999), admitted prior art and Wang, et al., (US 6,057,239) as applied to claim 14 above, and further in view of Tsai, et al., (US Patent 6,326,296 B1), is respect-

fully requested in view of the amendments and for the reasons given below.

Claim 14, as amended previously, cites the fill material comprising I-line photo resist, which the cited reference lack. Claim 14 also cites the removal of the excess fill material by chemical mechanical polishing. The method of chemical mechanical polishing is totally lacking in the cited prior art as well in references of Lin and Wang. In Wang, the sacrificial layer is anisotropically etched using plasma. Lin does not even use I-line photo resist as a fill material, and he/she too relies on etching, not chemical mechanical polishing, to remove the BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using etching. None of the cited references contemplate the problems associated with moisture when etching filling

materials specifically in dual damascene structures, and the attendant volcano effect.

In view of the amendments and the reasons given above, it is believed that base claim 14 is now clearly distinguishable from the cited references, and therefore, allowable, and hence also claims 17 and 20 dependent from claim 14, and it is so requested, respectfully.

It is respectfully suggested that the combination of these various references cannot be combined without reference to applicant's own invention. None of the applied references address the problem of via poisoning or volcano effect. Applicant has claimed his process in detail. The processes of Figs. 2a-2i (Claims 1-27 as amended) are believed to be novel and patentable over these various references, because there is not sufficient basis for concluding that the combination of claimed elements would have been obvious to one skilled in the art. That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of these various references is desirable. The use of an I-line photoresist and removal of the same using chemical mechanical polishing in forming dual damascene structures is not contemplated by any one of

the cited references. We believe that there is no such basis for the combination. We therefore request respectfully that examiner Kin Chan Chen reconsider this rejection in view of these arguments and the amendments to the claims, and allow claims 1-27 as amended.

Allowance of all claims, as amended, is requested.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned **"Version with Marking to Show Changes Made."**

It is requested that should the Examiner not find that the Claims Allowable that are now presented, that he/she call the undersigned Attorney at 845/452-5863 to overcome any problems preventing allowance.

Respectfully submitted,

A handwritten signature in black ink, appearing to be 'SBA', with a stylized, flowing script.

Stephen B. Ackerman, Reg. No: 37,761

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

The following claims have been amended as follows:

1. (TWICE AMENDED) A method of eliminating volcano effect in dual damascene comprising the steps of:

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providing a substrate having first and second insulative layers, optionally separated from each other by an intervening etch-stop layer formed thereon said substrate;

forming a hole opening through said first and second insulative layers;

forming a fill material over said substrate, including in said hole opening, wherein said fill material comprises I-line photo resist;

removing any excess fill material over said hole opening, wherein said removing said any excess fill material is accomplished by chemical mechanical polishing, or by etching;

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forming a trench opening in said second insulative layer
over said hole opening in said first insulative layer, thus
21 completing the forming of said dual damascene structure on
said substrate;

24 removing said fill material from said hole opening;

depositing metal in said dual damascene structure; and

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removing excess metal to complete the forming of said dual
damascene without the volcano effect.

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Claim 10 has been cancelled.